CLAIMS

1. A device configured to convert a hydrogenous fuel source to electrical energy, said device comprising a first reactant input, a second reactant input, a humidified reactant output, a diffusion media configured to pass multiphase reactants within said device, and a controller configured to operate said device at high relative humidity, wherein:

said controller is configured such that a relative humidity of said humidified reactant output exceeds about 150%;

said diffusion media comprises a diffusion media substrate and a mesoporous layer;

said diffusion media substrate comprises a carbonaceous porous fibrous matrix defining first and second major faces;

said mesoporous layer is carried along at least a portion of one of said first and second major faces of said substrate and comprises a hydrophilic carbonaceous component and a hydrophobic component;

said hydrophilic carbonaceous component comprises a low surface area carbon characterized by a surface area of below about 85 m^2/g and a mean particle size of between about 35 nm and about 70 nm.

2. A device as claimed in claim 1 wherein said hydrophilic carbonaceous component comprises a low surface area carbon characterized by a surface area of between about 60 m^2/g and about 80 m^2/g.

3. A device as claimed in claim 2 wherein said hydrophilic carbonaceous component comprises a major portion of said low surface area carbon and a minor portion of carbon graphite in addition to said low surface area carbon.

4. A device as claimed in claim 1 wherein said hydrophilic carbonaceous component comprises a low surface area carbon characterized by a mean particle size of about 42 nm.

5. A device as claimed in claim 1 wherein said hydrophilic carbonaceous component is selected from carbon black, graphite, carbon fibers, carbon fullerenes, carbon nanotubes, and combinations thereof.

6. A device as claimed in claim 1 wherein said hydrophilic carbonaceous component comprises acetylene black.

7. A device as claimed in claim 1 wherein said mesoporous layer comprises between about 90 wt% and about 95 w% of said carbonaceous component.

8. A device as claimed in claim 1 wherein said mesoporous layer comprises greater than about 80 wt% of said carbonaceous component.

9. A device as claimed in claim 1 wherein said hydrophobic component comprises a fluorinated polymer.

10. A device as claimed in claim 1 wherein said mesoporous layer defines a thickness of less than about 15μm.

11. A device as claimed in claim 1 wherein said mesoporous layer defines a thickness of about 10μm to about 12μm.

12. A device as claimed in claim 1 wherein said mesoporous layer at least partially infiltrates said diffusion media substrate.

13. A device as claimed in claim 1 wherein said mesoporous layer infiltrates said diffusion media substrate to a depth of less than 5μm.

14. A device as claimed in claim 1 wherein said mesoporous layer is characterized by a porosity greater than a porosity of said fibrous matrix of said diffusion media substrate.

15. A device as claimed in claim 1 wherein said substrate comprises carbon fiber paper.

16. A device as claimed in claim 15 wherein said carbon fiber paper is characterized by a porosity of above about 80%.

17. A device as claimed in claim 15 wherein said carbon fiber paper defines a thickness of between about 100μm and about 300μm.

18. A device as claimed in claim 1 wherein said substrate is characterized by a mean pore size of above about 25μm.

19. A device as claimed in claim 1 wherein said substrate is characterized by a mean pore size of between about 25μm and about 35μm.

20. A device as claimed in claim 1 wherein said controller is configured such that said relative humidity exceeds about 150% absent humidity regulation elements within said device downstream of said diffusion media and prior to said humidified reactant output.

21. A device as claimed in claim 1 wherein said controller is configured to regulate a relative humidity of at least one of said first and second reactant inputs such that said relative humidity of said humidified reactant output exceeds about 150%.

22. A device as claimed in claim 1 wherein said controller is configured to regulate temperature, pressure, humidity, and flow rates of said first and second reactant inputs such that said relative humidity of said humidified reactant output exceeds about 150%.

23. A device as claimed in claim 1 wherein said controller is configured such that a relative humidity of said humidified reactant output is about 300%.

24. A device as claimed in claim 1 wherein said device comprises a fuel cell.

25. A device as claimed in claim 24 wherein said device further comprises structure defining a vehicle powered by said fuel cell.

26. A device as claimed in claim 1 wherein:

said hydrophilic carbonaceous component comprises acetylene black characterized by a surface area of between about 60 m2/g and about 80 m2/g;

said mesoporous layer comprises less than about 80 wt% of said carbonaceous component;

said hydrophobic component comprises a fluorinated polymer selected from PTFE, PVDF, PVF, and combinations thereof;

said mesoporous layer defines a thickness of less than about 15μm;

said diffusion media substrate comprises carbon fiber paper characterized by a porosity of above about 80% and defining a thickness of between about 100μm and about 300μm; and

said controller is configured to regulate temperature, pressure, humidity, and flow rates of said first and second reactant inputs such that said relative humidity of said humidified reactant output exceeds about 150%.

27. A device configured to convert a hydrogenous fuel source to electrical energy, said device comprising a first reactant input, a second reactant input, a humidified reactant output, a diffusion media configured to pass multiphase reactants within said device, and a controller configured to operate said device at moderate relative humidity, wherein:

said controller is configured such that a relative humidity of said humidified reactant output is between about 100% and about 150%;

said diffusion media comprises a diffusion media substrate and a mesoporous layer;

said diffusion media substrate comprises a carbonaceous porous fibrous matrix defining first and second major faces;

said mesoporous layer is carried along at least a portion of one of said first and second major faces of said substrate and comprises a hydrophilic carbonaceous component and a hydrophobic component;

said hydrophilic carbonaceous component comprises a moderate surface area carbon characterized by a surface area of between about 200 m^2/g and about 300 m^2/g and a mean particle size of between about 15 nm and about 40 nm.

28. A device as claimed in claim 27 wherein said hydrophilic carbonaceous component comprises a moderate surface area carbon characterized by a surface area of about 250 m^2/g.

29. A device as claimed in claim 27 wherein said hydrophilic carbonaceous component comprises a low surface area carbon characterized by a mean particle size of about 30 nm.

30. A device as claimed in claim 27 wherein said mesoporous layer defines a thickness of between about 10μm and about 20μm.

31. A device as claimed in claim 27 wherein said mesoporous layer infiltrates said diffusion media substrate to a depth of less than 10μm.

32. A device as claimed in claim 27 wherein said substrate comprises carbon fiber paper characterized by a porosity of between about 70% and about 80%.

33. A device as claimed in claim 32 wherein said carbon fiber paper defines a thickness of between about 150μm and about 300μm.

34. A device as claimed in claim 27 wherein said substrate is characterized by a mean pore size of between about 20μm and about 30μm.

35. A device as claimed in claim 27 wherein said mesoporous layer comprises greater than about 80 wt% of said carbonaceous component.

36. A device configured to convert a hydrogenous fuel source to electrical energy, said device comprising a first reactant input, a second reactant input, a humidified reactant output, a diffusion media configured to pass multiphase reactants within said device, and a controller configured to operate said device at low relative humidity, wherein:

said controller is configured such that a relative humidity of said humidified reactant output is below about 100%;

said diffusion media comprises a diffusion media substrate and a mesoporous layer;

said diffusion media substrate comprises a carbonaceous porous fibrous matrix defining first and second major faces;

said mesoporous layer is carried along at least a portion of one of said first and second major faces of said substrate and comprises a hydrophilic carbonaceous component and a hydrophobic component;

said hydrophilic carbonaceous component comprises a high surface area carbon characterized by a surface area of above about 750 m^2/g and a mean particle size of less than about 20 nm.

37. A device as claimed in claim 36 wherein said hydrophilic carbonaceous component comprises a moderate surface area carbon characterized by a surface area of between about 800 m^2/g and about 1300 m^2/g.

38. A device as claimed in claim 36 wherein said mesoporous layer defines a thickness of between about 10μm and about 40μm.

39. A device as claimed in claim 36 wherein said mesoporous layer infiltrates said diffusion media substrate to a depth of less than 25μm.

40. A device as claimed in claim 36 wherein said mesoporous layer infiltrates said diffusion media substrate to a depth of between about 20μm and about 25μm.

41. A device as claimed in claim 36 wherein said substrate comprises carbon fiber paper characterized by a porosity of between about 70% and about 75%.

42. A device as claimed in claim 41 wherein said carbon fiber paper defines a thickness of between about 190μm and about 300μm.

43. A device as claimed in claim 36 wherein said substrate is characterized by a mean pore size of less than about 25μm.

44. A device as claimed in claim 36 wherein said mesoporous layer comprises greater than about 80 wt% of said carbonaceous component.

45. A device as claimed in claim 36 wherein said mesoporous layer comprises between about 90 wt% and about 95 wt% of said carbonaceous component.

46. A process for fabricating a diffusion media for a device configured to convert a hydrogenous fuel source to electrical energy at an operational relative humidity, said device comprising a first reactant input, a second reactant input, a humidified reactant output, a diffusion media configured to pass multiphase reactants within said device, and a controller configured to operate said device at said operational relative humidity, said process comprising:

identifying said operational humidity as a low, moderate, or high operational humidity, wherein said low operational humidity is characterized by a relative humidity at said humidified reactant output of below about 100%, said moderate operational humidity is characterized by a relative humidity at said humidified reactant output of between about 100% and about 150%, and said high operational humidity is characterized by a relative humidity at said humidified reactant output of above about 150%;

configuring a diffusion media such that said diffusion media comprises a carbonaceous porous fibrous matrix defining first and second major faces and a mesoporous layer carried along

at least a portion of one of said first and second major faces, wherein said mesoporous layer comprises a hydrophilic carbonaceous component and a hydrophobic component; and

configuring said mesoporous layer such that

said hydrophilic carbonaceous component comprises a high surface area carbon characterized by a surface area of above about 750 m^2/g and a mean particle size of less than about 20 nm where said operational humidity is identified as said low operational humidity,

said hydrophilic carbonaceous component comprises a high surface area carbon characterized by a surface area of between about 200 m^2/g and about 300 m^2/g and a mean particle size of between about 15 nm and about 40 nm where said operational humidity is identified as said medium operational humidity, and

said hydrophilic carbonaceous component comprises a high surface area carbon characterized by a surface area of below about 85 m^2/g and a mean particle size of between about 35 nm and about 70 nm where said operational humidity is identified as said high operational humidity.